PB-230 176

INTERSTATE POLLUTION OF THE HOLSTON RIVER VIRGINIA-TENNESSEE

Federal Water Quality Administration
Atlanta, Georgia

June 1970

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

PB 230 176

INTERSTATE POLLUTION OF THE HOLSTON RIVER

VIRGINIA - TENNESSEE

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER QUALITY ADMINISTRATION
SOUTHEAST REGION
ATLANTA, GEORGIA

JUNE 1970

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

TABLE OF CONTENTS

Section	Title	Page
I	INTRODUCTION	1
II	CONCLUSION AND RECOMMENDATIONS	4
III	PRESENT CHLORIDE AND HARDNESS CONCENTRATIONS . .	6
IV	EVALUATION OF PRESENT CONTROL	8
V	WASTE CONTROL AND ABATEMENT ALTERNATIVES	10
	A. Control Alternatives	10
	B. Abatement Alternatives	14
VI.	ECONOMICS	15
	A. Current Damages	15
	1. Quantified	15
	a. Current Recreational Damages	15
	b. Current Industrial and Domestic Damages	16
	2. Not Quantified	18
	B. Projected Damages	19
	C. Benefits	20
	D. Summary of Economic Damages and Potential Benefits	21
	APPENDIX	

LIST OF TABLES

No.	Title	Follows Page
1	SUMMARY OF CHLORIDES AND HARDNESS EVALUATED . .	7
2	FREQUENCY AND SOURCE OF DATA	7
3	PERCENT OF TIME THE CONCENTRATIONS OF CHLORIDES EXCEEDED 5,000 mg/1 AT SALTVILLE, VIRGINIA . .	8
4	AVERAGE ANNUAL PREVENTABLE PROJECTED DAMAGES DUE TO HARDNESS	19

INTERSTATE POLLUTION OF NORTH FORK HOLSTON RIVER

I. INTRODUCTION

This report summarizes pertinent data gathered since the second session of the Enforcement Conference (June 19, 1962) on the matter of interstate pollution of the North Fork of the Holston River. The Olin Corporation manufactures 1,000 tons per day of soda ash by the Solvay process at Saltville, Virginia. The waste by-product from this process is 1,920,000 pounds per day of chlorides as both calcium chloride and sodium chloride. Calcium increases the hardness of water and thereby increases the cost to potential and existing domestic, agricultural and industrial users. It is estimated that about 1,500,000 pounds per day of calcium hardness is produced as waste at the Olin plant. The average daily waste flow is 2.25 million gallons.

Olin's waste is impounded in a storage area having a present capacity of 60 days waste production. The Virginia Water Control Board in 1956 required Olin, in a special order, to release wastes in coordination with stream flow in the North Fork such that the chloride concentration in the river immediately below the discharge does not exceed 5,000 mg/l.

In accordance with the Water Quality Act of 1965, the State of Virginia, as part of its submission of water quality standards for all interstate and coastal waters to the Secretary of the Interior, established chloride criteria for the North Fork of the Holston River. The chloride concentration below Saltville was not

to exceed 5,000 mg/l at any time. The chloride concentration at Gate City, Virginia, just upstream from the Virginia-Tennessee state line was to be less than 1,000 mg/l at least 50% of the time; less than 2,000 mg/l at least 80% of the time; and less than 3,000 mg/l at least 96% of the time. The Secretary of the Interior, in his letter of acceptance to the Governor of Virginia on February 19, 1969, specifically excluded the chloride criteria for the North Fork of the Holston River. He directed that these criteria be established through agreement at a reconvened session of the Enforcement Conference. On January 6, 1970, the Virginia Water Control Board conducted a public hearing concerned with revision of the water quality standards for the North Fork of the Holston River. The Board has proposed a criterion of 500 mg/l of total dissolved solids (TDS) for the North Fork in Virginia.

Tennessee has not established a chloride or total dissolved solids criterion for the four miles of the North Fork within that state. Tennessee has established a criterion of 500 mg/l of total dissolved solids (TDS) in the Holston River below the confluence of the North and South Forks.

Based on 40 samples collected from the North Fork at Gate City, Virginia just upstream of the Virginia-Tennessee state line on December 1-3, 1969, chlorides represented an average of 55% of the TDS with 90% of the values falling between 52% and 57%. The corresponding mean percentage of hardness to chlorides during this period was 72% with 90% of the values falling between 67% and 77%.

The second session of the Enforcement Conference, held in June 1962, recommended the formation of a Technical Committee to investigate the effect of various alternatives in reducing chloride concentrations in the upper Holston River basin. This Committee evaluated four waste control measures. Economic data has been assembled detailing presently quantifiable damages resulting from the waste discharge.

The Office of Saline Waters, U. S. Department of the Interior, has developed a proposal for evaporating and recovering the calcium chloride waste product. This proposal represents an abatement measure and would result in a substantial reduction in the mass of waste discharged to the North Fork.

This report will evaluate the operation of the waste discharge facilities and summarize the present condition of water quality and its effects on uses of the water affected due to high chloride and calcium hardness concentrations.

II. CONCLUSION AND RECOMMENDATIONS

The Olin Corporation is currently causing at least $1,900,000 per year in quantifiable water hardness damages to present water users in Virginia and Tennessee due to its discharge of calcium and sodium chloride from its soda ash plant at Saltville, Virginia. The future damages in terms of increased costs to water users are much greater. The present annual equivalent value of these future damages is approximately $4,500,000 figured at 6% interest.

Only one of the control measures evaluated (a waste pipeline to downstream of Morristown, Tennessee) will alleviate damages that are greater than the cost of the pipeline. However, this alternative is unsatisfactory since only a part of the total damage will be eliminated. All damages downstream of Morristown, Tennessee amounting to 42% of the total will remain unaffected.

Olin Corporation's present control practice of waste impoundment with release integrated with river flow is not satisfactory. The present operation of the waste discharges, as determined by analysis of releases during 1964, is not efficient enough to meet the historical Virginia criterion (5,000 mg/l chlorides).

If the present waste storage ponds are expanded, chloride and hardness concentrations on the North Fork will not be reduced to a level permitting other domestic and industrial uses nor will it affect significantly the presently occurring concentrations in the Holston River below the confluence.

A proposed abatement process using evaporators to recover dry calcium and sodium chloride would essentially eliminate all damages caused to downstream users by the Olin waste discharge. The estimated annual cost could be as much as $1,600,000 excluding disposal of the dry by-product. This cost and the cost of disposal of the by-product may be partially offset by reuse of the sodium chloride and sale of some of the calcium chloride.

Therefore, to eliminate the quantifiable and non-quantifiable present and future damages to water users in the North Fork Holston, Holston, and Tennessee River caused by the Olin discharge, it is recommended that:

1. The State of Virginia establish criteria of 500 mg/l of total dissolved solids and 250 mg/l of chlorides at all points on the North Fork of the Holston River.

2. The State of Tennessee establish the same criteria of 500 mg/l of total dissolved solids and 250 mg/l of chlorides on the North Fork of the Holston River, the Holston River and the Tennessee River.

3. Olin Corporation discharge not more than 31,000 pounds per day of chlorides to the North Fork at all times so as to meet the above recommendation at the once in 10 year, 7-day low flow of 23 cfs at Saltville. This represents a 98.4% reduction of the present daily waste production.

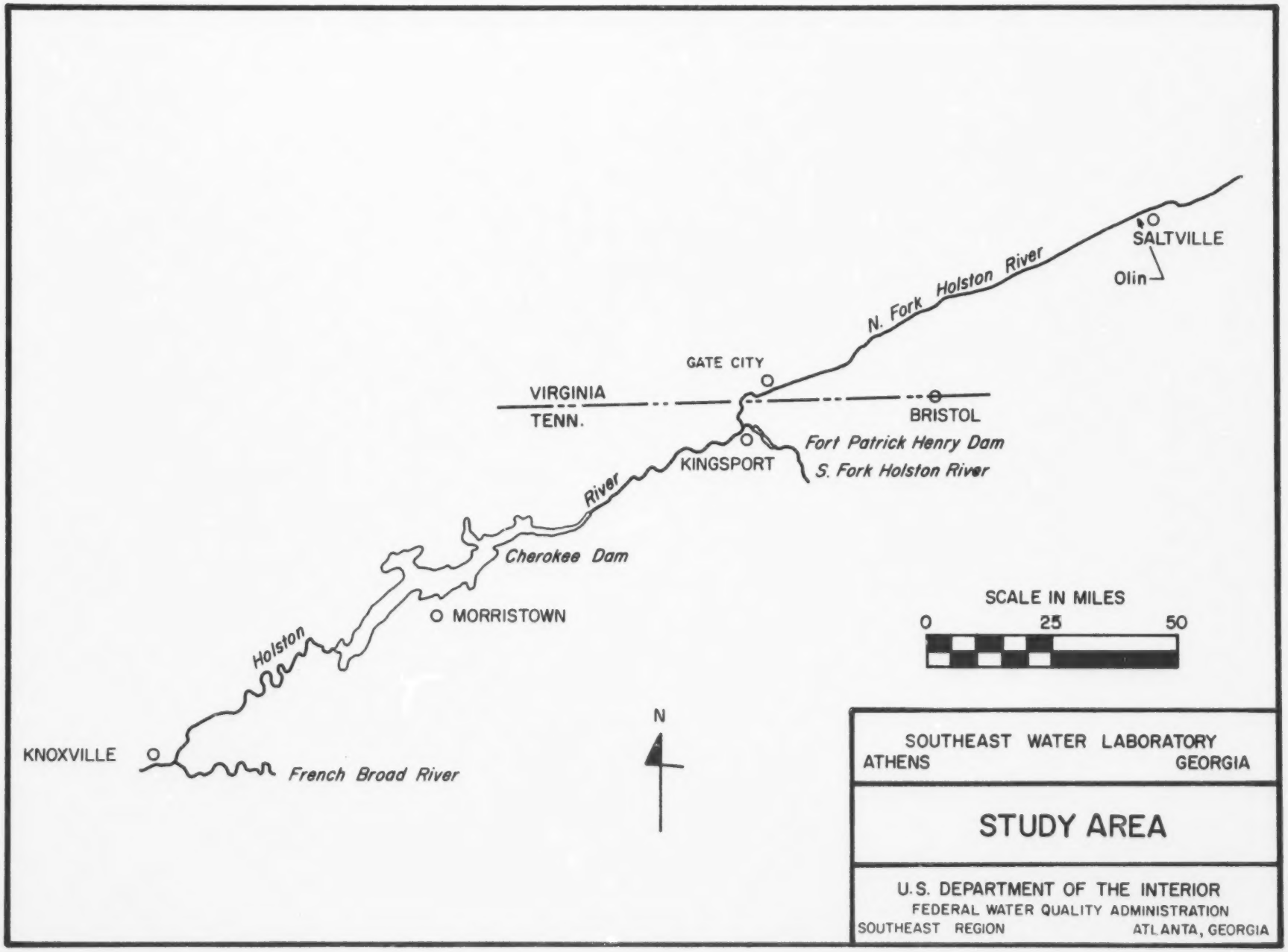
III. PRESENT CHLORIDE AND HARDNESS CONCENTRATIONS

A location map of the river basin under consideration is shown in Figure 1. The latest available data for the Holston River for chlorides and hardness are listed in Table 1. Most of the information presented in this table was compiled by a private consultant to FWQA.[1] The chloride concentration in the North Fork below Saltville was abstracted from data collected by an FWQA automatic monitor between February and November, 1964. The number of samples and period of collection are shown in Table 2.

The average concentration of chlorides in the area under consideration would be between eight and 15 mg/1 in the absence of the Olin waste discharge. In the North Fork the average concentration below Saltville is 336 times greater than background. Flow from the South Fork, which has an average annual discharge nearly three times greater than the North Fork (2532 cfs vs. 860 cfs), significantly dilutes the concentration to a computed average value of 375 mg/1. No observed data are available in the Holston River immediately below the confluence because the chloride and hardness concentrations preclude use for water supply. The chloride concentration at the Knoxville water supply intake is about four times greater than the computed natural concentration.

[1] Letter report on chlorides and hardness in the Holston River, Water Services, Inc., Knoxville, Tennessee. August 13, 1969.

FIGURE 1


SALTVILLE
Olin
N. Fork Holston River
GATE CITY
VIRGINIA
TENN.
BRISTOL
Fort Patrick Henry Dam
S. Fork Holston River
KINGSPORT
River
Cherokee Dam
MORRISTOWN
Holston
KNOXVILLE
French Broad River
N
SCALE IN MILES
0
25
50
SOUTHEAST WATER LABORATORY
ATHENS
GEORGIA
STUDY AREA
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER QUALITY ADMINISTRATION
SOUTHEAST REGION
ATLANTA, GEORGIA

6-a

Background hardness concentrations in the basin would normally range between 70-102 mg/l. The calcium hardness concentration below Saltville is 39 times greater than background due to the waste discharges at Olin. Below the confluence the computed hardness concentration is 237 mg/l or about 2.6 times greater than background. At Knoxville, the observed hardness concentration of 116 mg/l is about 1.5 times higher than the computed background value of 75 mg/l.

TABLE 1

SUMMARY OF CHLORIDES AND HARDNESS EVALUATED[1]

Stream Reach	Maximum Conc.		Natural Background		Average		Avg. Difference Attributable to the Olin Plant Discharge		Observed Range	
	Chlorides (mg/1)	Hardness (mg/1) $CaCO_3$	Cl (mg/1)	Hardness (mg/1) $CaCO_3$	Cl (mg/1)	Hardness (mg/1) $CaCO_3$	Cl (mg/1)	Hardness (mg/1) $CaCO_3$	Cl (mg/1)	Hardness (mg/1) $CaCO_3$
R-1a North Fork Holston[2] (Saltville)	6620	6050	8	70	2690	2738	2682	2668	385-6620	440-6050
R-1b North Fork Holston[3] (Gate City)	6475	1510	8	70	1419	633	1411	563	34-6475	110-1510
R-2 South Fork Holston[3]	262*	438*	15	102	15	102	0	0	14-262	66-438
R-3 Confluence to Church Hill[4]	1852	712	9	92	375	237	366	145	19-1852	77-712
R-4 Church Hill to below John Sevier (Am. St.[3] Gobain, Holliston Mills)	481	450	9	98	156	206	147	108	56-481	121-450
R-5 John Sevier to French Broad (Morristown,Tenn.)[3]	310	396	9	98	52	195	43	106	0-310	108-396
R-6 French Broad to Lenoir City (Knoxville,Tenn.)[3]	175	190	11	75	45	116	34	41	6-175	52-190

(1) All values except monitor data are from grab samples.

(2) From FWPCA Monitor data, 1963-64.

(3) From Water Services, Inc. report.

(4) Calculated from a weighted avg. of concentrations observed in the North and South Forks based on avg. annual flows.

*Includes samples collected from diversion wall as well as Kingsport water supply intake.

TABLE 2

FREQUENCY AND SOURCE OF DATA

Reach	No. of Samples	Date of Collection	Collected By
1a	Continuous (Saltville)	2/64 - 11/64	FWPCA
1b	31	3/63 - 6/68	Holston Ordnance
2	31	3/63 - 6/68	Holston Ordnance
3	Computed		
4	4	3/31/69 - 4/3/69	Amer. St. Gobain
4	39	10/63 - 12/67	Holliston Mills
4	292	1/63 - 1/69	John Sevier Steam Plant
5	500	1964 - 1967	Water Plant Morristown, Tenn.
6	600	1964 - 1968	Water Treatment Plant Knoxville, Tenn.

IV. EVALUATION OF PRESENT CONTROL

Discharge of waste from the Olin Corporation storage ponds previously has been governed by the 5,000 mg/l chloride limit imposed by the Virginia Water Control Board in 1956. Since 1963, the storage capacity of the ponds has been 60 days of waste production. As a result of the second session of the Enforcement Conference, the chloride concentration in the North Fork of the Holston River below Saltville was monitored by the Federal Government from June 1963 through November 1964. A computer simulation of waste release operations using material balance techniques and assuming constant waste production indicated that, for the actual flows in the North Fork during the 1964 storage period, approximately 57 days waste storage was necessary to meet the 5,000 mg/l constraint at all times.

Table 3 is a summary of the monitor data from February to November 1964 and indicates the percent of time during each month that the chloride concentration in the river exceeded 5,000 mg/l. According to the simulation, initial waste impoundment would have been necessary on June 11, 1964, and the peak storage would have been reached on October 15, 1964. It would have been possible to completely empty the impoundment by December 17, 1964. In actual operation, the standard was exceeded an average of 34% from June through November 1964 with a maximum of 84% during September 1964 although adequate impounding capacity was available. It would appear, from inspection of these data, that the control over releases from the storage ponds was not sufficient to meet the 5,000 mg/l requirement

TABLE 3

PERCENT OF TIME THE CONCENTRATIONS OF CHLORIDES EXCEEDED 5,000 mg/l AT SALTVILLE, VIRGINIA
(North Fork Holston River, February to November, 1964)

MONTH	MEAN MONTHLY FLOW (cfs)	% TIME CONCENTRATION OF Cl EXCEEDED 5,000 (mg/l)
2/64	385	0.0
3/64	880	0.0
4/64	490	0.0
5/64	132	0.0
6/64	80	10.1
7/64	46	15.1
8/64	34	12.9
9/64	33	83.7
10/64	93	76.9
11/64	115	2.1

of the Virginia Water Control Board, particularly when the capacity of the lagoons was approached as demonstrated by the excessive occurrences of greater than 5,000 mg/l chlorides observed below the ponds. At the present time, the plant regulates releases based upon chloride concentration in the river below Saltville. This method is not adequate as a control measure.

V. WASTE CONTROL AND ABATEMENT ALTERNATIVES

A. Control Alternatives

The Tennessee Valley Authority, at the request of the Holston River Technical Committee, developed analytical evaluations, preliminary designs and cost estimates for several potential control measures.(2) Most of these control measures had been suggested at previous sessions of the Enforcement Conference as possible solutions to the problem. However, no detailed quantified analysis had ever been performed. These proposals would not reduce the total mass of waste discharged to the receiving waters, but by taking advantage of high stream flows and depending upon the point of discharge, erratic occurrences of very high concentrations of chlorides and hardness could be lessened or eliminated, thereby presumably making the water more suitable for limited agricultural, domestic and industrial use.

The four proposals considered by the Tennessee Valley Authority were:

1. A pipeline to transport wastes to a point where river flow is sufficient to maintain chloride concentrations below 250 mg/l. Two discharge points were considered; the first at Church Hill, Tennessee, on the Holston River about 10 miles below the confluence of the North and South Forks, and the second at Morristown, Tennessee, to the Cherokee impoundment on the Holston River. A pond to regulate discharges in accordance with river flow would be required at Church Hill.

(2)Possible Plans for Alleviating the Saltville Pollution Problem, a Preliminary Study, Tennessee Valley Authority, Knoxville, Tennessee. September, 1969.

The average annual cost for capital amortization, operation and maintenance for a pipeline to Church Hill, Tennessee, is estimated at $681,000. All annual cost values were computed at 4 7/8% interest. This alternative would eliminate estimated present average annual damages from hardness amounting to $630,000 in the North Fork and the 10 miles of the Holston below the confluence. About $1,270,000 in current average annual hardness damages would be unaffected in the reaches downstream to Lenoir City, Tennessee. A pipeline with a discharge point at Morristown, Tennessee would require an annual cost of $896,000. This would result in elimination of hardness damages totalling $1,100,000 annually upstream of Morristown. About $800,000 in present annual damages downstream from Morristown would be unaffected.

2. Flow augmentation from Fort Patrick Henry reservoir on the South Fork to maintain chloride concentrations in the Holston River below the confluence at less than 250 mg/1. The present guaranteed minimum daily flow from Fort Patrick Henry reservoir is 750 cfs. To meet the requirement for additional flow would cost $691,000 annually, primarily in lost power revenues. Concentrations of hardness and chloride in the North Fork would not be affected at all and current average hardness damages would not be materially affected in any reach. Unevaluated damages because of above average additional hardness contributed by the Saltville plant (periodic "slugs") could be affected in reaches below the confluence through reservoir management by smoothing out the variations around the average.

3. Arbitrary daily base flows of 750 cfs, 1,000 cfs and 1,500 cfs respectively from Fort Patrick Henry Dam with the maintenance of a 5,000 mg/l chloride constraint at Saltville on the North Fork. This alternative evaluates the effect of South Fork flows in controlling chloride concentrations below the confluence. With the present minimum daily flow of 750 cfs from the South Fork, chloride concentrations below the confluence will be less than 250 mg/l approximately 86% of the time on a daily basis. At 1,000 cfs, the 250 mg/l constraint will be met about 89% of the time. At 1,500 cfs, the figure is 91%. Therefore, a 100% increase in the low flow requirement would produce a 5% improvement in the period when chloride concentrations would be less than 250 mg/l. As with the previous alternative, it is difficult to evaluate the effect of minimum releases since, in this case, the constraint will continue to be exceeded a certain percentage of the time.

4. Construction of a regulating reservoir on the North Fork just above the confluence to control releases such that the 250 mg/l chloride constraint was never exceeded below the confluence. This proposal would accomplish the same objective as the flow augmentation from Fort Patrick Henry reservoir, but the cost would not be in lost generating capacity. Two designs submitted would cost $693,000 and $603,000 annually and would not alleviate any of the quantified damages.

In none of the alternatives, except the pipelines, will current average damages be affected materially. The pipeline control measures will alleviate only a part of the problem. The flow augmentation

measures will not affect any of the damages quantified from the average values of hardness observed in the Holston River.

The Federal Water Quality Administration, Southeast Region, has analyzed the effect on chloride concentrations in the North Fork of increasing the storage capacity in the waste holding ponds. The hydrological record examined was from January 1932 through September 1967 on a daily basis. This analysis showed that, to meet the requirements of the special order issued by the Virginia Water Control Board in 1956 specifying a maximum chloride concentration of 5,000 mg/l below Saltville, a storage volume of at least 90 days waste production is required at Olin. Present capacity of the waste impoundment is about 60 days. The reduction in chloride concentration that can be attained below Saltville by expanding waste storage capacity becomes limiting at 3,000 mg/l because the necessary increase in capacity compared to the expected stream flow in the North Fork makes it impossible to ever completely empty the ponds.

Below the confluence, a 250 mg/l chloride concentration can be maintained 86% of the time given a 5,000 mg/l constraint at Saltville and 750 cfs base flow in the South Fork. If the constraint at Saltville is 3,000 mg/l, the 250 mg/l figure below the confluence will be maintained about 87% of the time. Similar improvements (about 2%) can be shown for base flows of 1,000 cfs and 1,500 cfs from the South Fork.

B. Abatement Alternatives

The Office of Saline Water, Department of the Interior has developed a preliminary design and cost estimate for an evaporator process to produce a dry waste at the Olin plant.(3) The method proposed includes the separate recovery of sodium and calcium chloride in solid form by means of vertical tube evaporators and crystalline driers at the ammonia still in the Solvay process. This would result in a production of between 840 and 1000 tons per day of calcium chloride depending upon plant production levels. The waste discharge to the North Fork could be essentially eliminated. The capital cost is estimated at approximately $6 million. The maximum figure quoted for amortization of the capital, operation and maintenance is $4,300 daily or $1,570,000 annually. This figure does not include disposal of the dry calcium chloride. Disposal may be as much as an additional $2500-$3000 per day or about $1,000,000 annually. This is a gross cost and not a net expense for implementation of the abatement measure. It is likely that these costs could be reduced by reuse of the recovered sodium chloride in the process and/or sale of the calcium chloride. Implementation of this abatement alternative would eliminate quantified current hardness damages downstream to Lenoir City, Tennessee, of approximately $1,900,000 annually. The present annual equivalent value of quantified damages eliminated now and in the future amount to approximately $4,500,000. In addition, unquantified damages from chlorides and other hardness considerations would also be eliminated.

(3)Memorandum and letter report. Assistant Secretary for Water Quality and Research to Undersecretary of the Interior. October 17, 1969.

VI. ECONOMICS

A. Current Damages

1. Quantified

As a result of the second session of the Enforcement Conference, an economic analysis of damages, existing and potential, resulting from increased hardness concentrations discharged by Olin, was performed.(4) This section abstracts pertinent information from this report. The stream reaches under consideration are defined in the appendix.

Average concentrations of chlorides and hardness resulting from Saltville discharges are much higher in Reach 1 than in the other reaches. Quantified economic and social damages, however, are much lower in this reach than in the other downstream reaches because of the dearth of development in this area. Due to rough terrain, inadequate transportation facilities, and the lack of good water-front industrial sites, the North Fork downstream of Saltville is not expected to experience intensive development. However, there are clear indications that some industrial development has been precluded in the past and will continue to be foregone in the future because of the high salt concentrations in the North Fork Holston River. It has been impossible, thusfar, to quantify these damages in this area as well as in areas farther downstream. Consequently, the preventable damages shown in this section for this reach are only those which could be estimated at this time. All economic values are presented in terms of current constant dollars.

(a) Current Recreational Damages

Current annual damages from reduced fishing and loss of recreational

(4) Summary Report of the Economics of Interstate Pollution of the North Fork of the Holston River, Virginia-Tennessee, November 1969, Economic Subcommittee to Enforcement Conference.

opportunities downstream from Saltville because of waste discharges are as follows (rounded to nearest $100):

Affected Stream Reaches	Net Value Base*	Increased Expenditure Base
1	$ 6,700	$ 32,700
3	500	2,400
4	1,700	8,400
TOTAL	8,900	43,500

*The "net value base" is considered as equivalent to the additional cost base used for other purposes. Consequently, these values are the ones included in all summaries.

(b) Current Industrial and Domestic Damages

Most of the damages quantified for purposes of this report were developed jointly by representatives from FWQA, TVA and Water Services, Inc., a Knoxville based water supply firm retained by the public agencies as a consultant on economic effects. The industrial and domestic damages are summarized as follows:

Stream Reach	Current Damages from Additional Hardness		
	Industrial	Domestic	Total
3	$ 616,000	$ -	$ 616,000
4	150,000	312,000	462,000
5	12,000	105,000	117,000
6	105,000	577,000	682,000
TOTAL	883,000	994,000	1,877,000

Damage estimates were also obtained from other sources. The North Kingsport Utilities District currently serves one school and about 900 domestic customers, but serves no industries. The flow from developed springs in dry weather is insufficient to serve the 900 domestic customers. Recently, the Utilities District was forced to refuse service to a subdivision of 240 homes within its legal boundaries because of inadequate sources of municipal water.

The subdivision will be served by the Church Hill, Tennessee system. According to available information from the Utilities District's consultant and from its manager, current annual damages to North Kingsport Utilities District are conservatively estimated at $4,500.[5] These damages, though very real, represent additional capital investments aggregating approximately $55,260 which are already "sunk" and cannot be prevented by future action in alleviating the condition causing it.[6] However, an approximately equal amount can be saved annually, as a minimum, between now and 1980, when the Utilities District is expected to serve its maximum number of domestic customers, if the District is able to use water from the North Fork Holston River (Reach 1b). Consequently, an annual domestic damage of $4,500 is estimated and included as an item of preventable future damages for this reach of stream.

TVA's John Sevier Steam Electric Plant, located at the headwaters of Cherokee Reservoir, also suffers from the increased hardness levels in the Holston River. Plant engineers estimated that their operating costs are currently increased by $1500 a year by the pollution from Saltville because of added hardness. This annual damage is estimated to continue to the year 2000, at which time the facility is expected to be phased out. Consequently, the $1,500 annual damage is projected to continue to the year 2000 and then drop to zero by the year 2020.

The total of all current quantifiable damages from Saltville, Virginia to Lenoir City, Tennessee is $1,891,900 per year.

(5) Total annual equivalent value of capital costs (stated as annual damages) is computed by ascribing 2½% of capital cost as annual operation and maintenance costs (consultant's advice) and adding in the amortized value of the capital cost for a 40-year life facility at 4 7/8% interest (the specified Federal discount rate for water resource projects).

(6) Ibid.

2. Not Quantified

Presently unquantifiable damages in the Holston and Tennessee River basins under consideration result from sporadically high and unexpected concentrations of chlorides and hardness; effects of increased chloride concentrations; lack of industrial development due to excessive hardness concentrations; and the use of less desirable sources of domestic water supply.

Sporadic occurrences of unexpected high concentrations of hardness and chlorides are more difficult to cope with than uniform conditions. The damages result from the inability of the domestic and industrial water users to anticipate these unexpected conditions.

Increased chloride levels can add costs to the use of water for cities and industries, particularly where heat and/or high velocity processes are involved. These damages are usually manifested in the pitting of equipment and piping.

Certain industries such as textile or bleached pulp and paper operations require very high quality water supply which is low in chlorides. For both of these industries, concentrations of chlorides in excess of 100 mg/l are usually considered unacceptable. Therefore, industries may not choose to locate in areas of excessive hardness and chloride concentrations even though other factors such as raw materials, transportation facilities or labor supply may be satisfactory.

The use of the South Fork of the Holston River as a source of municipal supply for the Kingsport area was alluded to at the first session of the Enforcement Conference. Although the South Fork receives enormous amounts of untreated industrial waste, this use is necessary due to the grossly excessive concentrations of calcium hardness in the North Fork above the confluence.

Other damages which have not presently been quantified are those occurring downstream from Lenoir City, Tennessee and the normal increase in per capita consumption of water both upstream and downstream.

B. Projected Damages

Because fishery and recreation potential in all stream reaches of this area are expected to be utilized to capacity almost immediately upon being made usable, and since future annual values cannot exceed capacity, all future annual damages to fishing and recreation are shown as identical to current annual damages. All projections are measured in constant current dollars.

Damages attributed to hardness alone have been projected in three parts:

1) Future additional cost of soap and detergents to domestic users has been projected in relation to increases in population served by municipal water systems.

2) Water treatment costs for indicated growth of new industries.

3) Water treatment costs for indicated growth of new industries under the assumption that certain industries would locate in these areas despite the current quality. Growth during the most recent 10-year period more than substantiates such an assumption.

The total projected damages have been summarized in Table 4. The present total damage is $1,891,900 annually. This is projected to increase to $3,695,500 annually by 1980; $6,954,500 per year by 2020; and $8,811,600 annually by 2020.

TABLE 4

AVERAGE ANNUAL PREVENTABLE PROJECTED DAMAGES DUE TO HARDNESS

Type of Damage	Annual Damages in Current Dollars[1] Projected 1980	2000	2020
Recreation[2]	$ 8,900	$ 8,900	$ 8,900
Domestic[3]	1,404,500	1,942,500	2,492,500
Industrial[4]			
Excess costs of operation:			
Existing Plants	964,000	1,072,000	1,208,000
New Plants	1,296,000	3,890,000	5,050,000
Excess capital costs:			
Existing Plants	14,100	18,100	22,200
New Plants	8,000	23,000	30,000
Total	$3,695,500	$6,954,500	$8,811,600

[1] Constant current dollars--1968-69 period of study used as base period. Current waste discharges at Saltville are assumed to continue unchanged into the future. Demographic and economic growth is assumed to continue along the "normal" growth path established by the Tennessee and Virginia Social Sciences Advisory Committees and the Office of Business Economics. The estimated mix of growth of major "waterfront" industries was more directly determined through analysis of site availability and suitability as well as market orientation (TVA branch-plant analysis).

[2] Fishing and related activities. The current need equals or exceeds capacity of the unpolluted stream.

[3] Increased costs for soaps and synthetic detergents only. Other deleterious effects of hardness (such as reduced life of pumps, pump impellers, distribution systems, hot water heaters, clothes, linens, and so on) are not included. Chloride damages, per se, are not included.

[4] Additional hardness caused by Saltville wastes only. Chloride damages, per se, are not included. Included are increased costs of (1) water softener operation, (2) boiler operation, including increased fuel costs, and (3) cooling tower operation.

The non-quantifiable projected damages would be the extension of those presently occurring and discussed previously, due to expanded population and the concomitant increase in domestic use as well as the growth of new and existing industries.

C. Benefits

As previously discussed under the control alternatives, the only proposals which could materially affect current and potential damages are the pipelines to either Church Hill, Tennessee or Morristown, Tennessee. Through bypassing upstream areas, these proposals would effectively eliminate damages in these sections. This damage elimination may be treated as a benefit and projected to future values. The total potential benefit in all stream reaches under consideration due to elimination of the waste discharge may also be summarized.

1. Pipeline to Church Hill, Tennessee

Annual benefits presently quantified for the proposed pipeline taking wastes from Saltville and discharging them into the Holston River near Church Hill, Tennessee, at river mile 133.6 amount to:

Current	1980	2000	2020
$630,000	$660,000	$660,000	$660,000

2. Pipeline to Morristown, Tennessee

Current	1980	2000	2020
$1,100,000	$2,200,000	$4,300,000	$5,500,000

3. Total Potential

Damages in all stream reaches can be reduced to zero by a pipeline of sufficient length to bypass all reaches affected downstream to Lenoir City, or by reducing the waste discharge to zero at Saltville. The latter alternative would, of course, have the advantage of reducing to zero any damages which occur downstream from Lenoir City.

Current	1980	2000	2020
$1,900,000	$3,700,000	$7,000,000	$8,800,000

D. Summary of Economic Damages and Potential Benefits

The total quantifiable preventable average annual damages in current dollars due to excessive hardness concentrations in the North Fork Holston, Holston and Tennessee River from Saltville, Virginia to the Lenoir City, Tennessee water intake amount to $1,900,000 presently (1968-69) and are expected to increase to $8,800,000 by 2020. Damages not quantified are occurring from: sporadic occurrences of wide variations in high calcium hardness and chlorides; excessive chloride concentrations; industry and domestic use foregone due to unacceptable inorganic pollution; excessive concentrations downstream of Lenoir City; and additional costs due to normal increases in per capita consumption of water.

The only control alternatives proposed which could measurably affect the damages are a pipeline to either Church Hill or Morristown, Tennessee. A pipeline to Church Hill would produce undiscounted annual benefits (due to alleviation of damages in bypassed reaches) of $630,000 currently increasing to $660,000 by 2020. A pipeline to Morristown, Tennessee would result in an undiscounted annual benefit of $1,100,000 currently and $5,500,000 by 2020. The present

annual equivalent value of benefits using a discount rate of 4 7/8% are about $650,000 for the pipeline to Church Hill, Tennessee and $3,000,000 for the pipeline to Morristown, Tennessee.

The quantified present annual equivalent value of current and future benefits for a complete elimination of damages from Saltville, Virginia to Lenoir City, Tennessee is $4,500,000 using a 6% discount rate.

APPENDIX

APPENDIX I

V. ECONOMICS

1. Analytical Method and Procedure

Damages presented are based on point averages at water intakes as observed in the Water Services, Inc. Report.[1] For example, technical data values at the Holston Army Ammunition Plant are considerably lower than the average for the reach in which it is located because a large part of the intake water actually comes from the South Fork rather than the North Fork.

In order to evaluate proposed alternative solutions in terms of benefits likely to accrue to each, and to account for progressive changes in the average concentrations of waste in response to dilution as they progress downstream from the point of discharge, stream reaches were delineated and used to develop the most meaningful values practicable in terms of both technical and related economic estimates. Reaches delineated for use in the study are described as follows:

Reach	Stream	Limits
1a	N. Fork Holston River	Saltville, Va. to location to proposed regulating dam near R.M. 9 (Gate City, Va.)
1b	N. Fork Holston River	Proposed regulating dam to confluence of N. & S. Forks, Holston River (near Kingsport, Tenn.)

[1] Water Services, Inc., Knoxville, Tennessee.

Reach	Stream	Limits
2	S. Fork Holston River	Ft. Patrick Henry Dam to confluence of North & South Forks Holston River (Near Kingsport, Tenn.).
3	Holston River	Confluence of North and South Forks to proposed pipeline outfall at R.M. 133.6 (near Church Hill, Tenn.).
4	Holston River	Proposed first pipeline outfall at R.M. 133.6 to second proposed outfall at R.M. 67.5 --below City of Morristown, Tenn., water intake.
5	Holston River	Proposed second pipeline outfall to confluence of French Broad and Holston Rivers.
6	Tennessee River	Confluence of French Broad and Holston Rivers to below Lenoir City, Tenn., water intake.

To evaluate alternative solutions to the damage problem in a meaningful manner, technical and economic estimates by stream reaches were developed. A stream-reach approach was also required because the concentrations of waste materials in the affected streams are further diluted as they progress downstream from the point of discharge.

Estimates presented are based on averages. However, variations about the average are significant, and to the extent practicable, they have been recognized and taken into account. It has not been found possible, however, to place a meaningful average dollar value on these variations for purposes of this study.

County population projections, developed by Virginia and Tennessee Social Sciences Advisory Committees, and residential employment projections developed by the Office of Business Economics (OBE) and by TVA personnel and related to Committee population projections, provided an overall control of more localized projections required for purposes of this study. The county projections were

accomplished within the general framework of national, regional and Economic Area projections provided by OBE (Census Bureau's Schedule "C" projections at the national level).

Analysis of industrial directories and other data sources provided the detail needed with regard to the type, character, size and specific location of existing industrial plants in areas under study.

Projections are based on normal existing conditions and development in each county. They do not consider the elimination of specified impediments to economic growth and development, nor do they consider the desirable available resources in each area if certain restrictions are eliminated. Statements have been made in public hearings that industrial development has been foregone in areas adjacent to both the North Fork Holston River and the Holston River due to poor water quality. To verify those statements it is necessary to determine if the area has potential for economic growth and if so, to what extent. Analysis of the area showed that it does have great potential for industrial development.